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Test Results of the SeaKeepers Ocean Sensor Module on Remote Platforms

Catherine Woody
National Data Buoy Center
1100 Balch Blvd.
Stennis Space Center, MS
39529-6000

Rodney Riley,
Nikolai Fedoroff,
Terry Rutledge
Science Applications
International Corporation
Stennis Space Center, MS
39529-6000

Geoffrey Morrison,
Rod Zika
International SeaKeepers Society
UM RSMAS
4600 Rickenbacker Causeway
Miami, FL 33149

***Abstract*-The National Data Buoy Center (NDBC) and the nonprofit International SeaKeepers Society have adapted the SeaKeepers Ocean Sensor Module (OSM) to NDBC platforms and data collection systems. The reason for this effort was to develop a low maintenance system for oceanographic data collection and transmission from remote platforms. The OSM has been integrated into a 3-meter buoy and underwent nine months of dockside testing for performance and durability of the electronics and antifoulant system and to verify the quality of the data. It was deployed in the Gulf of Mexico near buoy station 42007 for verification of that station's meteorological data. Test results have shown that the OSM and antifoulant system performed well in remote, harsh conditions. The results are presented in this paper.**

I. INTRODUCTION

Coastal waters are highly valuable ecosystems--not only in primary productivity and fisheries assessment and recruitment, but also with regard to coastal development, marine recreation and transportation, energy, and national security. Coastal waters are vulnerable to degradation from natural hazards such as severe storms or tsunamis and from cumulative impacts from anthropogenic sources. Sampling strategies for understanding anthropogenic loading within natural variability have improved with advancing technology development for satellite imagery, ship sampling, and continuous, *in situ* measurements. It is the *in situ* measurements that provide insight to episodic or short-time-scale events which are missed with periodic sampling [1]. When used in conjunction with satellite and ship observations, they provide an important mechanism for understanding biological and physical processes in coastal waters.

The National Data Buoy Center (NDBC) recognized the availability and utility of their platforms to collect oceanographic data from remote platforms; the nonprofit International SeaKeepers Society (SK) developed a low maintenance ocean data collection module [2]. NDBC and SK combined resources to adapt the SK oceanographic module to buoys, offshore towers, and piers. The ocean data collection system is the Ocean Sensor Module (OSM) originally developed by SK for real-time data collection from ships. It has been adapted to moored and fixed platforms for remote autonomous data collection. Because of space and power requirements, the first platform to be addressed was the 3-meter buoy. The second was adapting the OSM to a fixed platform.

To accomplish this, four challenges were addressed: 1) space limitations, 2) power requirements, 3) biofouling, and 4) reporting bandwidth using the Geostationary Orbital Environmental Satellite (GOES). The OSM box measures 75x40x25 cm and houses the pump and up to four multiparameter sensors. The OSM was mounted on the deck of the buoy (Fig. 1) with all the electronics housed within the module.

Because power was a primary concern in adapting the OSM to a 3-meter buoy, NDBC developed a low power embedded processor, the NDBC Oceanographic Sensor Interface Controller (NOSIC), to replace the SK computer module. To conserve space, it was embedded into the OSM box. The NOSIC interfaces the sensors with the buoy payload. Its primary functions are to: 1) acquire and process serial data from the sensors when polled by the payload; 2) control the pumping and biofoul cleaning systems; 3) store time series data to a flash memory card, and 4) report processed minimum, maximum, mean, and standard deviation of data to the buoy payload once per hour. The data are then transmitted thorough GOES.

Fig. 1. OSM external mount on a 3-meter buoy

To control biofouling, a pumping system is used which contains an electrochemical halogen-generating anti-fouling device called the 'sparker.' The sparker is turned on, and the wetted components cleaned. The sparker is shut off, and the pumping system draws water to the sensors.

The data were encoded to a compressed message size for transmission through GOES. The data enter the National Weather Service Telecommunications Gateway and are downloaded to NDBC for shoreside processing and posting to the Web site. A full description of the adaption of the OSM to the 3-meter buoy can be found in [3].

II. 3-METER BUOY TESTS

A. NDBC Dockside

The OSM was placed on a fully integrated 3-meter buoy and underwent testing in 3 phases. It was first deployed at the NDBC docks in freshwater. Power, NOSIC performance, pumping system, and data collection and transmission were monitored for four months, from July – October 2002. Power consumption was verified by added laboratory instrumentation and load current measurements were compared to the estimated power budget. The oceanographic data were checked for reasonableness. No corruption was found on the wind direction data by activation of the pump. Gross checks on the meteorological data from the buoy were compared to the meteorological data at NDBC's operational test facility. The system performed well. Minor adjustments were made to the NOSIC software and mechanical placement of the sampling pipe mount.

B. Gulfport Harbor

Upon completion of the dockside testing, the buoy was moved to a Navy facility at the Gulfport Harbor in Gulfport, MS. Testing began in November 2002 and continued through March 2003. The harbor offered a secure environment with saltwater and superb fouling. The intent was to leave the system in the water through the spring bloom to test the performance of the sparker.

Data from each sensor were monitored daily. Each hour the pump and sensors were powered and data collected for 4 minutes. Initialization or settling of the sensors appeared to vary. Part of the intake hose lies across the buoy surface and is subject to heating and cooling. This caused erroneous data to be reported. Sufficient time had to be allowed to flush the residual water out of the hose. Several time series data sets of each parameter were obtained and analyzed for settling times. A special 45-minute time series was recorded for each parameter to verify the initialization times. It was determined that the last 2 minutes of collected data (4-minute set) would be processed for transmission.

The sparker performed well. The sensors were checked periodically; after 6 months, very little fouling occurred (Fig. 2). No antifouling paint was used on the external parts of the hose and hose mount. During spring warming, the outside of the pump hose and intake screen clogged from heavy growth. The sparker was moved from inside the hose down to the inlet screen, but results showed that fouling increased on the sensors. The sparker was moved to its original position, and antifouling paint has been applied.

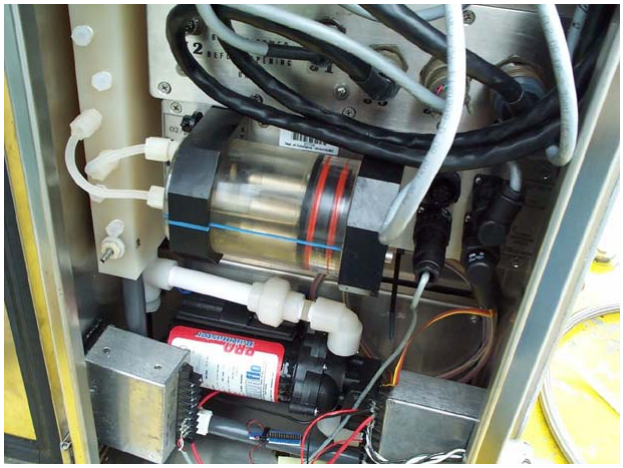

Fig. 2. Sensors in OSM enclosure

The power system performed as expected through the winter months. Minor software adjustments were made to the NOSIC for data acquisition and processing and readjustment of the cleaning cycle.

C. Gulf of Mexico

To become operational within the NDBC guidelines, certification of the OSM integration and verification of the meteorological data has to occur. Certification involves testing to assure that NDBC's standard meteorological data collection and transmission are not corrupted and the function of the new addition operates properly with reasonable data reported. Time series data are also collected and evaluated. Data loss and irregularities (e.g., spikes or flat line signals) are noted. Causes of data irregularities are analyzed through graphics, data comparisons, and housekeeping information such as voltages, load currents, pump pressures, and quality assurance/quality control (QA/QC) procedures.

The buoy was deployed in June of 2003 in the Gulf of Mexico near buoy station 42007 (see Web site for location: http://www.ndbc.noaa.gov). The OSM, a SeaBird conductivity/temperature (c/t) sensor, and an Acoustic Doppler Current Profiler were added for certification. The following results were obtained:

- The meteorological data verification was completed. All parameters passed with the exception of relative humidity. A further comparison was checked against a C-MAN station at Dauphin Island. It is suspected that the benchmark station 42007 is in error. Further analyses will be conducted.

- The OSM housekeeping data passed with the exception of moisture detection. The sensor is located within the OSM box and recorded 'wet' for the test period. Inspection (not done at the time of this paper) will determine if the sensor read correctly.

- The ocean data met the requirements for reasonableness in their variations. The OSM sensor for temperature and salinity was compared to the SeaBird c/t and the buoy temperature.

A full report of the certification and verification can be obtained from NDBC.

Since there was no standard procedure to verify the ocean data, it was checked visually for reasonableness. Where possible, historical data were obtained to verify that the data fell within range. The salinity data from the OSM and c/t, and the temperature data from the OSM, c/t and buoy were compared (Figs. 3 and 4). The intake for the OSM is approximately ½ meter below the water; the c/t sensor is near 3 m, and the buoy temperature probe is in the buoy hull, also about ½ meter deep.

Preliminary analyses show the SeaBird values slightly higher for salinity and lower for temperature than the OSM (Fig. 3, 4). This would be expected, since the c/t sensor is slightly lower in the water column. The buoy temperature and OSM tracked extremely well (Fig. 4). The beginning effects of Tropical Storm Bill can be seen around June 27 in both figures. Preliminary investigation shows the differences seen in salinity are associated with southwesterly winds.

III. DATA

The meteorological data are collected and transmitted hourly through GOES. The data pass through a combination of automated and manual quality control checks and are posted to the Web site hourly. While QA/QC procedures have been developed for the real-time meteorological data, none (other than gross checks for quality), are in place for real-time oceanographic data. Factory calibration information for the sensors is applied to the data determination. At present, these data are appended to the GOES message with the basic quality checks and displayed on the Web in real-time. To alleviate this concern, NDBC will host a workshop in the fall of 2003 to begin algorithms development for flagging questionable data. An ocean portal will eventually be developed and implemented to bring the same standards to research and monitoring as those for the meteorological data.

IV. SUMMARY

NDBC and SK have successfully adapted the SK OSM to a 3-meter buoy. The system is fully automated and operates remotely. Results have shown that oceanographic data can be collected with low maintenance requirements. Data are being imported through real-time satellite transmission and reported hourly on the NDBC Web site. Standards and algorithms will be developed and implemented for the oceanographic data.

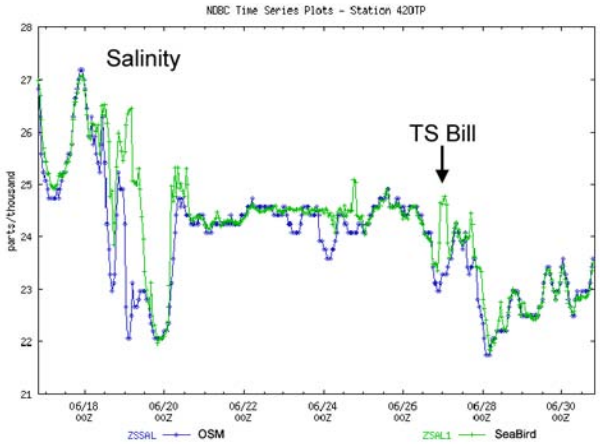

Fig. 3. OSM salinity measurements

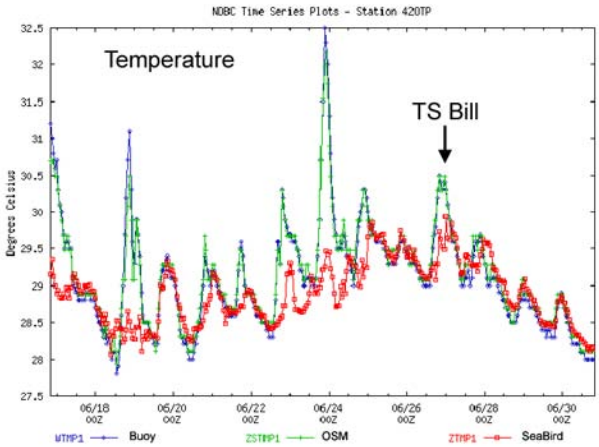

Fig. 4 OSM temperature measurements

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